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Quality Declared Planting Materials of Potato, Ethiopia

Reference Book for an Informal Seed Inspection System

By

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1. INTRODUCTION

1.1 The potato plant and its reproduction

Potato (*Solanum tuberosum* L) originated in the highlands of South America and is cultivated in 157 countries of the tropical, subtropical and temperate zones of the world (Stevenson, *et al.* 2001). *S. tuberosum*, is a tetraploid (2n=4x=48) plant which produces tubers under long-day conditions. It is traditionally grown from tubers, but it can also be grown from other vegetative organs such as stems or sprouts, and also from true seed. Tuber is an underground modified swollen that serves as a storage and reproductive organ. According to FAO (2010) potato plant has multiplication rate ranging from 1:10 to 1:15 and tuber has buds, also called "eyes", arranged in a spiral manner, from which sprouts and shoots develop. After harvest, the tuber undergoes a dormancy period of two to three months, during which development is temporarily suspended. Tubers of 40–60 g are commonly used as seed potatoes, larger tubers are cut into two to four pieces containing at least one eye.

1.2 Main seed-borne diseases and pests

There are many seed-borne diseases and pests of potato recorded in Ethiopia (Dereje and Gebremedhin, 2012; Ermias, 2010; Mesfin *et al.*, 2009; Ferdu *et al.*, 2009; Bayeh *et al.*, 2008; Bekele and Eshetu, 2008), but the most important are outlined in Table 1 below considering the disease/pest, causal agent, affected area, symptoms and preventive measures.

1.3 The importance of quality seed and supply system

Good quality planting material is one of the foremost prerequisites of healthy and successful crop production venture. Because, planting materials are important vehicle for innovative technologies and may eventually disseminate serious pests including disease causing pathogens, arthropods pests, and noxious weeds. In Ethiopia for instance, bacterial wilt was spread to many new Weredas of the Amhara and Tigray regions in just few years through infected seed tubers from Shashemene, a known hotspot area for bacterial wilt (Dereje and Gebremedhin, 2012). This kind of disease dissemination can occur for many important and serious seedborne diseases and pests if phytosanitary measures are not incorporated in seed production and distribution system. A known solution for this kind of problem is the production and distribution of high quality disease-free planting materials.

Table 1. Major seed borne diseases and pests of potato in Ethiopia

Disease/pest	Causal agent	Affected area	Disease symptoms	Preventive measures
Late blight	*Phytophthora infestans*	Leaves, stems and tubers	Blighting of the foliage, dark lesions on and in tubers	• Use clean planting material, • Use of resistant varieties, • Use fungicides • Plant out of season • Manage residues
Bacterial wilt	*Ralstonia solanacearum*	Tubers	Vascular rings of tubers go brown, leading to rotting of whole tuber	• Planting of clean seed, • Avoid sick fields, • Stick to local minimum rotation requirements, • Avoid contaminated tools, shoes, water, soil, etc • Remove volunteers plants • Rogue infected plants and throw it into pits or burn
Black leg/soft rot	*Erwinia carotovora* pv. *atroseptica*	Stems and tubers	Non-emergence or stunted pale green or yellow foliage, black stems and foliage easily pulled out. Tuber soft rot (black) extending from heel end.	• Planting of clean seed, • Avoid injuring tubers • Rogue infected plants and throw it into pits or burn • Avoid contaminated tools, shoes, water, soil, etc
Powdery scab	*Spongospora subterranean*	Tubers	Tubers erupt with edged scabs more circular than common scabs	• Crop rotation • Planting clean seed • Resistant variety
Severe mosaic	Potato virus Y	Leaves and tubers	Variable according to strain and variety. Mild to severe mosaics on leaves including leaf distortion. Necrosis of veins, leaves may shrivel and drop (primary symptom). Stunting. Tubers may show cracking or surface rings and internal necrosis in the case of infection of sensitive varieties with PVY	• Planting clean seed, • Keep isolation distance • Rogue infected plants (crop hygiene). • Use of resistant varieties. • Control vectors
Mild Mosaic	Potato virus X	Leaves	Mild mosaic pattern of light and dark green on leaves. No leaf distortion. Can cause severe symptoms in mixed infections with other viruses.	• Planting of clean seed, • Keep isolation distance • Use of resistant varieties • Rogue infected plants • Control vectors
Leaf roll	Potato leaf roll virus	Leaves and tubers	Rolling of lower leaves which may feel "crispy". Purplish color of young leaflets in primary infection. Net necrosis in tubers of some varieties	• Planting clean seed, • Keep isolation distance • Control vectors • Rogue infected plants (crop hygiene). • Use of resistant varieties.
Potato tuber moth	*Phthorimae operculella*	Leaf, stems and tubers	Rolling and eating leaves, boring stems and tubers	• Early planting • Insecticide spray or dipping • Several earth-up the field • Keep tubers in clean DLS

Thus, production and distribution of quality seed need serious attention and a well designed system that insures a separate value chain that is different from ware potato production. As a result, production of good quality planting materials should be properly designed to suit the circumstances of potato producers that exist in the country (Adane *et al.*, 2010). The system in turn influences many developmental, socio-economic, and environmental issues. A resilient and sustainable system addressing the specific needs of poor farmers for timely access to good quality planting materials with appropriate genetic, physiological and phytosanitary conditions plays a crucial role in ensuring food security and rural economic development.

The problems of potato farmers in Ethiopian demand for a systematic approach to deliver good quality planting material that accommodates all stakeholders involved in generation, delivery and uptake of potato technologies (Schulz *et al.,* 2012). To attain this, Ethiopia at this point needs to promote an on-farm production of quality declared planting materials (QDPM) of potato to improve the access of smallholder farmers to quality seed through decentralized local schemes.

In this QDPM system, farmers receive training in seed production and management that include variety and field selection, use of quality seed, rouging, variety maintenance, positive and negative selection, harvesting, and seed processing, storage, packaging and marketing. This chain of seed production activities are reinforced by locally on-farm operated quality control system. The quality control (at each step) is carried out at farm level by a Cooperative-level inspection team (COOPCOM) by means of applying good seed production practices (GSPP) and by a Wereda-level inspection committee (WERCOM) through properly designed inspection procedures. The inspection involves field and post-harvest assessment and data collection, which at the end validation of QDPM is done with official seal on labels (tags) for potato seed tubers. This system contains a procedure that farmers receive fresh and clean source materials every five years depending on the level of degeneration.

The success of this system depends on the ability of farmers to grow good potato crops, select the source of their planting materials, choose location and field at which they produce; pest and vector pressure in the production area, and the capability of WERCOM to maintain the service. If the system remains effective, it would revolutionize the supply of quality potato planting materials in Ethiopia and enhance trust of seed purchasers with better price, because farmers are accountable to their neighbors for the quality of their potato seed, the QDPM available at their locality.

1.4 What is QDPM scheme?

The QDPM scheme is a process that has an intention to guide the production of clean, disease-free planting materials of vegetatively reproduced crops (FAO, 2010). Its goal is mainly to raise the physiological and phytosanitary quality of planting materials available to smallholders, and hence, increases agricultural production and productivity. It is meant to be implemented primarily by seed producers at community level or field extension workers. A practical QDPM protocols and standards are used to allow easy monitoring and verification

of the production and distribution process. It complements and is agreeable to formal seed quality control systems in line with national and local conditions to ensure that they are appropriate and achievable for target users. It links the activities of research and extension to seed multiplication activities of smallholders.

QDPM protocols set clear roles for the public and the private sectors. Accordingly, the public sector is responsible for maintaining germplasm, introducing new materials, and producing clean source materials; while the private sector (especially seed producers) is responsible for mass multiplication and distribution of quality planting materials to ware-potato producers.

1.5 Why is QDPM important to potato growers in Ethiopia?

Studies on potato seed system in many parts of the world and in Ethiopia in particular clearly indicated that the first challenge to potato farmers at local level is the limited access to good quality planting materials (Adane, *et al.*, 2010). For vegetatively propagated crops like potato, formal seed supply to resource-poor farmers in particular is challenging in Ethiopia where there is no single seed producer handles potato. This is because it is relatively difficult to produce healthy potato, storage is not easy, it quickly degenerates in a few numbers of cycles. In such a system it is difficult to create a stable demand for seed supply.

According to FAO (2010) potato has an essential role in enhancing food security and human nutrition. It can also substitute other crops in cases of multiple use and economic needs. Producing the planting materials of potato presents intricate problems with many logistic issues for their extensive use. This is mainly important for smallholder farmers in Ethiopia (like in other developing countries) because:

- The formal seed system in the country doesn't accommodate potato at present;
- Farmers use traditional mixture varieties, including local ones;
- There is a lack of consistent supplies of good quality planting materials, although there is high demand for clean potato planting materials in the country;
- There is a lack of knowledge on phytosanitary measures and quarantine issues related to safe movement of germplasm, plants and planting material across borders;
- Serious potato seedborne diseases are spreading with seed tubers to many new areas, and
- The planting material in potatoes is bulky and perishable;

Evidences from other countries show that different ways can be designed to support local seed systems. In all the systems, most important is to establish sustainable, small-scale seed systems that operate by farmers themselves and address the needs of these small-scale farmers (Schulz, *et al.*, 2012). The challenge to it is may be that how to make the system sustainable in a big country like Ethiopia where many of the villages are at remote parts of the country. However, we have to take up these challenges and develop innovative, farmer-based supply system of potato planting materials that addresses the needs of rural potato growers.

1.6 Recognition on the value of good planting materials in Ethiopia

The basis of demand for quality planting material in potato is the recognition of its value for crop productivity. In many developing countries, perception of farmers in this regard is highly variable, ranging from specialized knowledge to lack of attention to even the basic features of quality. This is also true in Ethiopia (Adane et al., 2010; Agajie *et al.*, 20008). Although farmers have a notion that improved varieties give a number of benefits, they often undervalue the maintenance of good quality planting materials that may enables the expression of its genetic potential. At present, good work has been done in Ethiopia by research in raising awareness on the value of quality potato planting materials and varieties (Gebremedhin *et al.*, 2008a; Gebremedhin *et al.*, 2008b). In the last decade, HARC has been training farmers, men and women, in improving the quality of their potato seed by emphasizing tuber yield, disease and storage management, but now the time has come to consider separate value chains for seed and ware potato; by considering the developmental stage of agriculture in the country.

1.7 Assuring timely supply of affordable potato planting materials

The success of potato production in the country depends on timely delivery of good quality planting materials with affordable price (Schulz *et al.*, 2012; Adane, *et al.*, 2010; Ermias, 2010). Major bottlenecks for increased potato productivity and production in Ethiopia include (i) sustainable supply of clean planting materials, (ii) rising seed through good production practices, and (iii) quality assurance of these planting materials through inspection; QDPM at this early stage and possibly seed certification at a later stage. This new seed production model (scheme) needed to include a built-in quality assurance system through local seed producers and community institutions. It improves seed quality and helps them ensure well-timed delivery of good quality planting materials at their locality. In this system, production and distribution are totally integrated where farmers undertake production, processing, quality control and sales in the local community with the help of local Agriculture Offices and Research Centers. The client and supplier are neighbors, make the marketing easy, sell at competitive prices and enjoy trust in quality. Finally, resource-poor farmers become producers of good quality planting materials where quality assurance is carried out by their participation. They form wholesalers and retailers, and principal client groups within their locality maintaining the dynamics of QDPM and eventually preparing the ground for a formal seed system. In this new system, there is a seed flow of one direction (Figure 1).

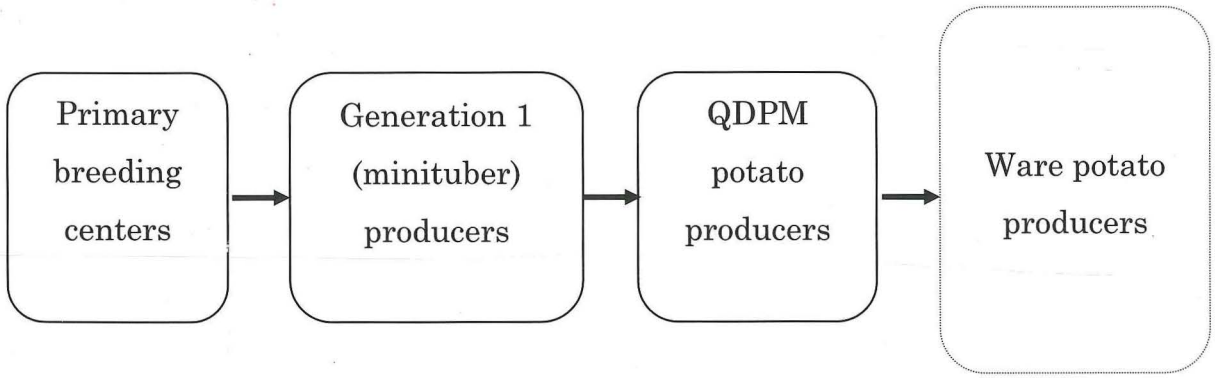


Figure 1. **Clean potato seed flow from primary breeding centers to ware-potato producers via generation 1/research centers and then QDPM producers [Adapted from Schulz *et al.* (2012)]**

As indicated in Figure 1 above, the primary breeding centers develop new varieties for different agro-ecologies and eventually produce disease-free in-vitro plantlets under good capacity/facility conditions. The facilities include tissue culture, aeroponic facility and insect proof screen houses/greenhouses. Materials produced under such conditions should be very useful and at the same time expensive. These invaluable materials are generation-1 and/or are further multiplied in research centers as generation-2. At this stage, research centers usually increase potato seed under Good Seed Production Practices (GSPP), which subsequently supplied to QDPM producers. The QDPM scheme contains an in-built quality control system and two tiered inspection procedures. Finally, the Good Quality Potato Seed Tubers produced under QDPM scheme is supplied ware potato produces. The seed produced under QDPM scheme fulfills the demands of ware potato producers in their locality with affordable price.

1.8 Long-term perspective

There is a huge demand for quality potato seed in Ethiopia, and hence, decentralization of seed production is a promising way forward by considering the size, diversity and cultural conditions of the country. This is because, it is difficult to fulfill the demand of potato seed as there is a trend of fast increase in potato production in many ports of the country and Ethiopia has a big potential of seed production because its endowed with many physical, edaphic and cultural diversities. However, the seed system is not well developed that the formal seed supply doesn't come reality very soon. So, QDPM serves as a transitional stage from informal to formal seed supply system for potato by preparing the potato industry to enjoy formal seed supply system in the future. The QDPM system outlined by FAO is not designed to replace a fully developed seed certification program, but proposes a complementary system which is less costly but still provides good quality planting materials in countries like Ethiopia with low capacity and limited resources for seed certification. Hence, the QDPM is an alternative way to reach small-scale farmers who do not have access to, and so do not use, certified seed for potato production. This system is expected to prepare a ground for the formal seed certification system which may come in the future.

2. GOOD SEED PRODUCTION PRACTICES AND INTERNAL QUALITY CONTROL

A field guide of Good Seed Production Practices (GSPP) for potato is an important tool serving as a checklist in field operation during production and quality control. It serves as guidance for potato seed producers with only important components that are directly related to the proposed informal seed inspection process. The content describes field selection and rotation, sources of planting materials, husbandry and protection practices, harvesting, post-harvest handling and storage particularly in DLS.

2.1 Field selection and crop rotation

Choose fields that are isolated from ware-potato fields by about 50 meters and avoid sites within traditional seed production areas. Consider fields that have not been planted with any *Solanaceous* crop for at least three years. Study the field history whether it has any potato

disease, particularly bacterial wilt in the past. This is because bacterial wilt is a difficult disease to control once it has established in potato field (Dereje and Gebremedhin, 2012). This information is useful to take necessary preventive measures against soil-borne pathogens. Rotation is very important in potato production to avoid contamination and soil borne diseases/pests. Preferable crops include cereals, *Brassica* species, and legumes.

2.2 Source of planting materials

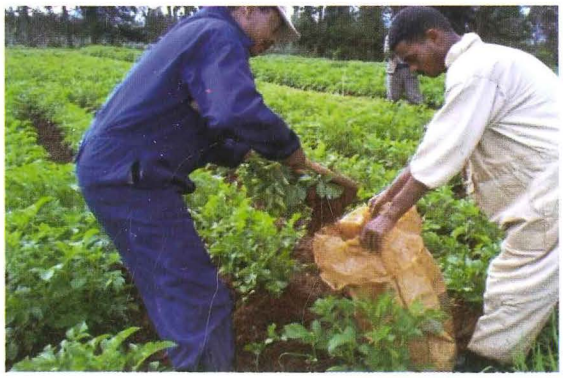
Always use healthy planting materials, preferably from known sources (particularly from research centers). Sort seed tubers before planting to minimize incorrect varieties (off-types) and avoid mixing varieties. This minimizes the risk of variety contamination and diseases in potato seed crop. Information about the source, the number of field generations, the results of any inspections that have been made are important in selection. Research Centers and/or Wereda Agriculture Office are main sources of information on any testing or inspection results and where it is found.

2.3 Husbandry and protection practices

Husbandry and protection practices are hearts of quality seed production that determines the planting value of a particular material. As a general rule, ridging, weeding, fertilizer and chemical applications for pest control should be implemented as recommended by trained members (Gebremedhin *et al.*, 2008a; Bayeh *et al.*, 2008; Bekele and Eshetu, 2008). However, specialized activities are necessary for seed crop unlike ware potato crop. These greatly influence the quality of seed produced. Most important ones are:

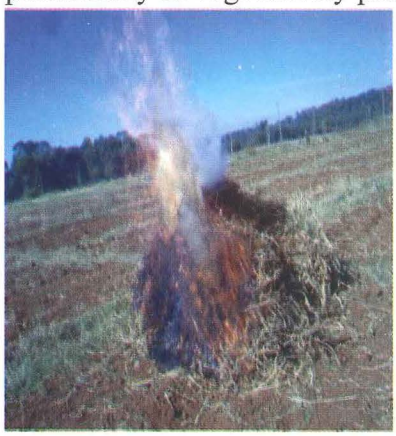
(i) Regular field inspection: Inspect the seed crop regularly for the presence of colonizing vectors that transmit viruses by examining the undersides of leaves. Control vectors using pesticides if the population of vector is medium or severe. Check the presence of off-types and diseased plants (for details refer to section 4) then rouge out carefully. These abnormal plants reduce the quality of tubers produced by the candidate seed crop.

(ii) Rouging abnormal plants: rouging is the recognition and removal of entire plants. Hence, remove all off-types (other varieties), volunteer plants and diseased looking ones from the seed crops starting four weeks after planting. Volunteer and diseased plants are sources of diseases. Destroy all plant refuses by burying and use of fire. Seed field entry should be restricted to the minimum. Conduct rouging every week during mornings of clear days. For additional information, reference should be made to a Crop Technology Book by EIAR (EIAR, 2005) and your seed production training documents.



Rouging diseased potato plant

(iii) Residue management: plant refuses/residues after harvest and grading should be collected and placed out of the field and processing areas in a protected pit. Use fire to destroy like in the figure below. This is because many pests survive on these trashes and complete their cycle. It serves as primary source of inoculums. Thus, proper residue management is one and very essential activity in pest management in modern seed production particularly in vegetatively propagated crops.



Burning potato trashes/residues

(iv) Disease and pest control: pests in wider sense include diseases, arthropods pests, weed species, etc. Pests in seed crops should be controlled not only to protect the yield but also to maintain the quality of seed harvested. Pesticides including fungicides and insecticides are indispensable weapon against these enemies in general. Against late blight, starting at the beginning of the disease spraying of Mancozeb at the rate of 3 kg/ha (repeated every 7-10 days) or Ridomil MZ at the rate of 2 kg/ha (ones or twice enough) can perfectly control in seed crop. To control potato tuber moth, tubers can be dipped in Diazinon suspension (20 ml in 10 liter water) before storage and in the field spray with Systemic carbamates, Organophosphates or Pyrethroids at recommended rate. The vectors can be controlled by spraying suspension of Primifos-methyl (1 liter/ha), Primicarb (2 kg/ha) or Roger (2 liters/ha) using water.

Deeping tubers in Diazinon suspension for PTM control

2.4 Harvesting and handling

Tubers should be harvested when they are physiologically mature that means when the peel (skin) is well set because immature tubers are prone to peeling during harvest and storage operations that may risk it to disease infection. Tubers can be induced to mature by cutting, pulling or killing the haulms 10–20 days before harvest. Early killing of haulms also can be used for pest control (particularly aphid borne viruses) and controlling seed size. Avoid

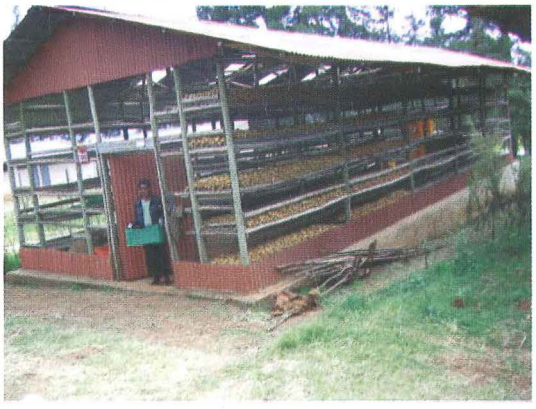
harvesting the seed potatoes when the soil is still wet or during rainy days, as the tubers will carry soil and be at risk of disease infection. If tubers are harvested wet, they should be dried before storage under no direct sunlight or heat.

2.5 Post-harvest handling and storage

To reduce infection by pathogens and water loss, cure seed potatoes for two weeks so that the outer layer of potato peel and the periderm thicken. Before storage, seed potatoes should be sorted to eliminate damaged, diseased and off-type tubers. Repeated seed examination and sorting is recommended during storage. Generally, seed tubers must be stored in diffused light store (DLS). DLS reduces sprouting and weight loss of tubers during storage, helps tubers turn green which increases resistance to pests, and allows farmers to store the seed for longer periods and thus increases yields. Storing tubers in the dark results in long weak sprouts and low tuber yield. Transportation is carried out with care to reduce physical damages to tubers.

Potato harvesting

Tuber sorting



Storing potato seed tubers in DLS

3. QUALITY DECLARATION AND THE STANDARDS

3.1 The Inspection and Decision Process

The inspection course of action and resulting decisions are illustrated in Figure 2. Accordingly, the two inspection teams operate hand-in-hand with different roles. The COOPCOM plays a crucial role of guiding the seed production process and ensures the internal quality control aspects basing its action on Good Seed Production Practices (GSPP).

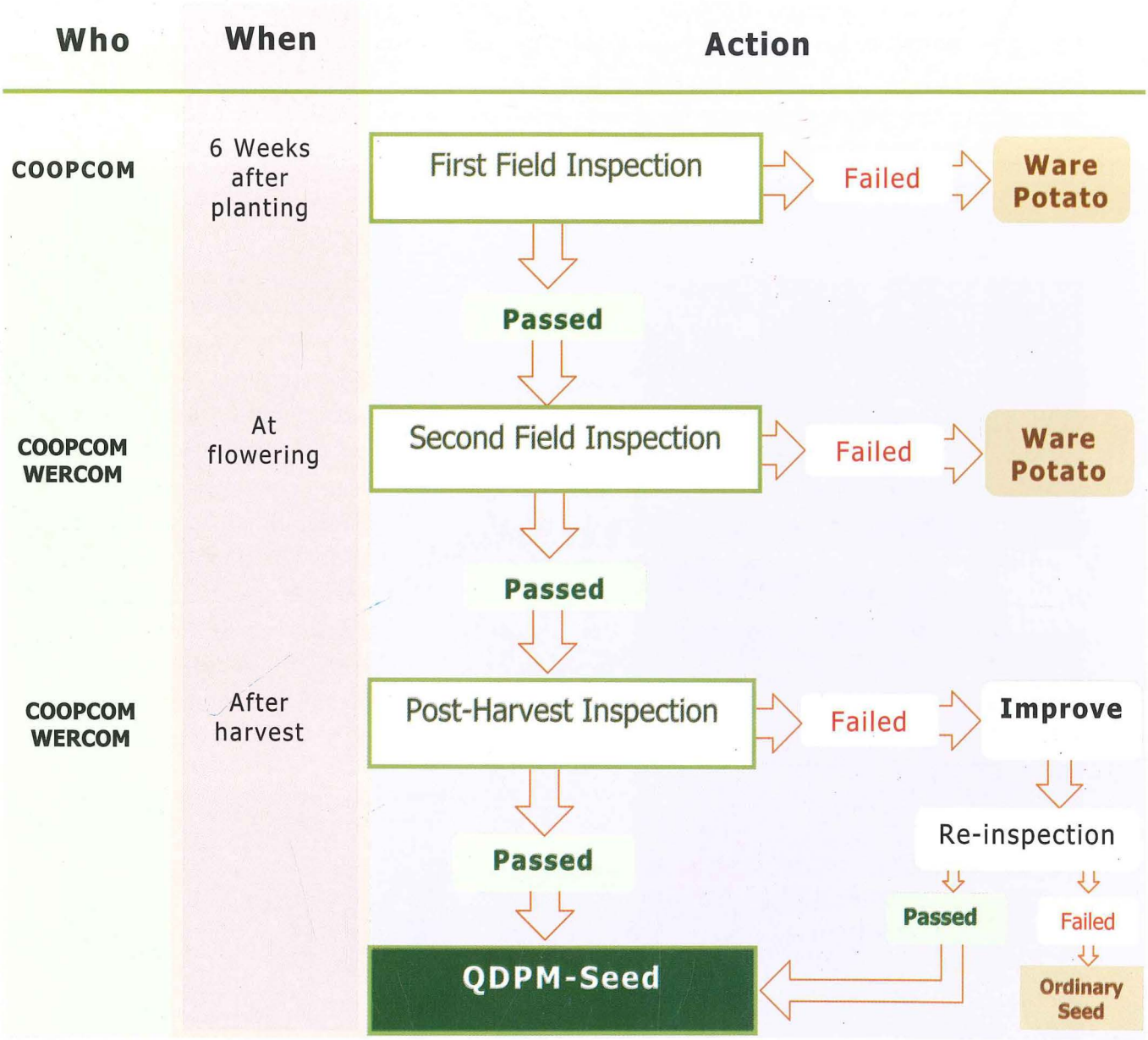


Figure 2. **Illustration of the QDPM inspection scheme designed for potato in Ethiopia**

The WERCOM plays a crucial role of verifying the QDPM standards and finally declares the resulting planting materials as QDPM-Seed. It also recognizes Coops/PLCs for every season and discloses the amount and kind of tuber seed available in its Wereda. Based on field and post-harvest inspection, first COOPCOM and finally WERCOM decide on the fate of the candidate seed crop as it is clearly stated in Figure 2. Finally, only those fulfilling the QDPM standards should receive tags as QDPM-Seed.

3.2 The Inspection Team and Its Members

The main purpose of regulatory scheme is imposing quality standards and control measures in production processes to guide the value chain. Thus, the QDPM suggested for potato here is the type of "informal" seed inspection system that deemed to ensure the timely supply of improved potato varieties and quality seed tubers from dependable sources, healthily produced and processed, truthfully labeled and declared, and trusted quality potato seeds to poor farmers at their locality. The system trusts on the continuous supply of source materials from trustworthy sources (research centers), technical trainings given by researchers and technical backstopping handled by the extension services, and financial availability from various sources (micro-finance, banks, and NGOs) either in support or otherwise. The quality assurance (seed inspection) is managed by a special Wereda-level Inspection Committee (WERCOM) and being assisted by a committee of each farmer group/cooperative (COOPCOM). The members in these two committees include:

A. **WERCOM:** This committee consists of 5 members (one seed agronomist from Wereda-BoA = chairperson, one plant protection/agronomy/ expert from Wereda-BoA = secretary, one researcher from Research Center working in the Wereda (optional) = member, the Development Agent (DA) closely working with the producer = member, and one elected representative of the Cooperative/PLC = member. Decision of the WERCOM is taken by majority vote, except when research is not represented the chairperson keeps the balance.

B. **COOPCOM:** inspection committee inspects all seed potato fields of members of the cooperative. The COOPCOM consists of 3 members elected by the members of the Cooperative. It is suggested that if possible one woman is included in the inspection team. Whenever necessary, decision of the COOPCOM is taken by majority vote.

3.3 Local Institutions Involved

The local organizations responsible for this inspection that are vital in assuring the QDPM for potato include the following.

(i) The main actors (producers): The kinds of producers directly involve in potato seed production under QDPM and responsible in the inspection and declaration processes are recognized by some criteria.

The **Cooperative/PLC** needs to fulfill the following formal criteria.

1. Registered by government of Ethiopia as Cooperative and has renewed license if PLC
2. Has an official seal
3. Has bank account
4. Can issue legal invoices
5. Has received potato seed production training by research in the last 3 years
6. Get its sources of materials from research (clean planting materials)
7. Willing to produce QDPM through successful internal quality control system
8. Differentiate seed potato from ware potatoes
9. Has DLS (diffused light store) capacity for all seed produced
10. Willing to grade seed tubers (in 40 to 70 g size)
11. Has a minimum of 5 ha land for potato seed production

(ii) Other stakeholders

1. Research Institutions (Federal, Regional, International/CIP Projects)
2. Bureau of Agriculture (Wereda-BoA)

3.4 TOR for Inspection Teams (WERCOM and COOPCOM)

Duties and responsibilities of WERCOM include:

- WERCOM inspects potato seed fields once during flowering stage and tuber quality once at post-harvest stage in DLS,
- It inspects all seed crop and all diffuse light stores (DLS) at present when the number is few in each Wereda, but as the number increases inspection is done by taking a sample of about 20% in each FGC,
- WERCOM performs inspection with majority members (at least three members present),
- The team carefully inspects each field and verifies all tolerance levels given in Table 2 and recommends necessary measures for the field and tuber in DLS. If recommendations are not accepted and accordingly corrected, the inspection team rejects the crop as QDPM,
- It registers the data collected from the field and DLS in forms prepared for it (one for field and the other for post-harvest recording),
- Assesses and verifies the field and post-harvest records obtained from COOPCOM inspection, in case WERCOM inspects fields taking sample,
- When one Coop has got >70% of its fields fulfilled the QDPM standards, WERCOM issues a letter of recognition as "**QDPM of Potato Producer Coop for the Year YYYY**", and
- Provides **tags** only for the amount of seed tubers produced and qualified for QDPM standards

Duties and responsibilities of COOPCOM include:

- COOPCOM inspects all seed fields 2 times in the season (first visit at 6-8 weeks after planting depending on the variety and location and then second visit at flowering), and tuber quality at post-harvest stage in DLS (regular inspection of tubers in DLS is necessary to maintain the quality),
- Advise members for field, DLS and variety labeling, and take corrective measures such as rouging, vector and pest control,
- Advise members to sort defective tubers and eventually grade seed tubers (40-70 g size) for QDPM quality standards in DLS,
- COOPCOM performs inspection with all members present and take decisions by majority vote whenever necessary,
- The team carefully inspects each field and tuber lot thereby verifies all tolerance levels given in Tables 2 and 3,
- It registers the data collected from the field and DLS in the forms prepared for the purpose (one for field and the other for post harvest),
- Provides the field and post-harvest records for WERCOM inspection team,
- Receives the **tags** for potato seed sacks qualifying QDPM standards, and hands it to the officials of Cooperative, and

- Reports the amount of seed tubers harvested, processed, labeled with tags, and available for sell in their DLS.

3.5 Ensuring sustainability

Simple application procedures tend to sustain in any system. Thus, very simple mechanism of operation is developed to effectively develop the QDPM for potato. In a step-by-step procedure, the following are very important components of the mode under operation.

- Establish availability of sources of clean potato materials,
- Train farmers on Good Seed Production Practices (GSPP) and quality control to specialize in seed production (routine extension support),
- Train the process of quality declaration through inspection procedures,
- Establish a forum for recognition of WERCOM members by local institutions every year,
- Establish a separate value chain for potato seed (QDPM) by registration and information exchange system at the Wereda Bureau of Agriculture, and
- Evaluate the system at Wereda-level every year and improve through full participation of local institutions.

4. INSPECTION PROCEDURES

4.1 Field inspection of potato for QDPM

General requirement and tolerance level:

Two basic requirements are always in picture when planning potato seed production that includes crop rotation of 3 years and isolation distance of about 50 meters (if possible) from other *Solanaceous* fields. Rotation is verified by studying the field history while isolation distance could be judged during inspection time.

Usually two inspection visits are recommended for field inspection of potato for QDPM validation. The periods of inspection are (i) the first visit at 6-8 week after planting depending on the variety and location, and (ii) the second visit at flowering stage. Data to be collected during field inspection is judged against the tolerance levels indicated in Table 2 for each requirement and tolerance level. The set of tolerance levels serve as guiding tool during inspection and final labeling of the potato seed in the QDPM system.

Table 2. Requirements and tolerance levels for field inspection in the QDPM scheme for potato

Requirements/defects/diseases	**Tolerance**
Rotation of at least	3 years
Incorrect variety (off-type)	1%
Bacterial wilt	Nil
Total viruses (leaf roll + mild mosaic + severe mosaic)	**5%**

How to perform field inspections:

Sampling during inspection differs according to the size of potato fields. Accordingly, inspection committee (WERCOM and COOPCOM) members should take data by first selecting the field and then selecting rows from each field depending on the size of the field. Data collection is carried out following the procedures described below.

A. Field Sampling

The primary requirement in potato seed production is a 3 year rotation system and 50 isolation distance (which is difficult in many parts of the country). Thus, WERCOM upon assessing the field history of a particular candidate potato field planted for QDPM validation, qualifies all fields where potato was not grown in that particular field for any of the last 2 years. Less than three years rotation is not accepted. And candidate potato field should be about 50 meters away from other ware potato (other *Solanaceous* crops) fields as a rule, but may be difficult in some parts of the country. In addition, proper field identification of a candidate crop is very important in inspection schemes for standard, where the following should be included in field labeling.

- Name of location (Cooperative, Seed enterprises)
- Name of variety
- Date of planting
- Evidence of rouging

B. Plant Sampling within a Field

(i) **For a field with 2 ha or less:** a total of 10 random rows of potato will be selected to assess. From each row 100 potato plants are checked for purity and diseases. Mean value of these 10 rows provides the single score for the field to be compared with the tolerance level.
(ii) **For a field greater than 2 ha:** an additional 5 rows (with 100 plants per row) should be assessed for every additional 1 ha field. The inspection team members should make counts while walking between rows in the field and even rogue abnormal plants.

C. Assessing for off-types and mark potential seed plants for future

Early Stage Inspection: This is an important practice carried out at early stage of potato growth and development (often completed up to early flowering period). In this inspection, off-types/ mixture and volunteer plants are assessed; diseases and vectors are easily observed and recorded at this stage. As a result of careful assessment, COOPCOM suggests important corrective measures including late blight control, vector suppression measures and rouging of defected plants from potato seed fields. Eventually the COOPCOM advices its members to selects and peg potential (big and healthy looking) potato plants that may serve as future seed plant for their own consumption upon harvesting separately at the end. COOPCOM ultimately calculates mean value of off-types for each field. Then check if the mean value for off-type is less than 1% to consider the field for further inspection for QDPM standards. Any field having greater than 1 off-type plant from 100 total plants checked is discarded from seed crop under QDPM (Table 2), but it can only grow as ware potato.

Flowering Stage Inspection: this inspection is carried out by WERCOM and COOPCOM during flowering stage of potato development. At this stage, each inspection committee

collect data (similar to the first inspection period) through careful assessment of seed fields and a mean value will be calculated by each committee for each field. Similar recommendations are expected from them to maintain quality. WERCOM then check if the mean value for off-type/mixture is less than 1% to consider the field to qualify for QDPM standards. Any field having greater than 1 off-type plant from 100 total plants checked is discarded from seed crop under QDPM (Table 2), but it can only be considered as ware potato field. Especial attention should also be given for physiological age of the material, uniformity, and estimated harvest of the crop as seed. At this stage, COOPCOM advices its members to remove the pegs from selected plants, if they found to be diseased.

D. Assessing for Diseases

In both early and flowering time visits, inspection teams should assess important potato diseases using the following descriptions. The symptoms of most important diseases are included support identification.

1. Late blight (*Phytophthora infestans*)

Late blight is a very important disease in potato and control is a must, otherwise it can devastate the crop. It also infects tubers that severely reduce tuber seed quality at harvest. Stem infection by late blight is a serious issue in seed crop because most stem infections in the field leads to tuber infection at the end of the season that may spread to new crop through seed tuber. Therefore, late blight control is strongly recommended for seed crops. Grow resistant variety and control the disease with the use of fungicides.

Leaf and stem symptoms

Susceptible variety wiped-out by late blight

2. Bacterial wilt (*Ralstonia solanacearum*)

Bacterial wilt is a serious tuber-borne and soil-borne disease of potato. Once a field is infested with this pathogen, it is very difficult to control. Hence, bacterial wilt is not allowed in any potato seed crop. Typical symptoms of bacterial wilt is include either as whole plant

wilted or tuber rotted, but to ascertain whether these symptoms were caused by bacterial wilt or not we need to dip-up some tubers and check for tuber symptoms. When there are no tubers then cut some stems and put them in water for about 10 minutes to observe whether bacterial ooze comes out from the vascular system. This is simple method of checking bacterial wilt in stem and tubers. **No bacterial wilt is allowed in potato seed field, because there is no tolerance level for it** (Table 2). Rouging is a must in any potato crop.

Single plant wilted in the plot

Whole plant wilting

Symptoms in the tubers

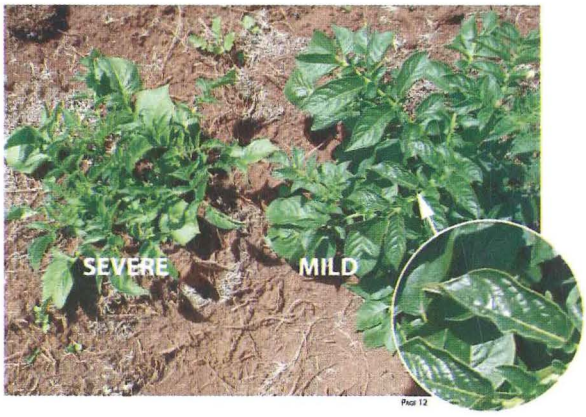
3. Different potato viruses

Many viruses infect potato, but the symptoms of most important ones are given here. The inspection teams (WERCOM and COOPCOM) at both field inspection periods look for plants with virus symptoms during mornings of clear days. All suspected plants should be rouged out. **Field with only 5% and less are accepted for QDPM standard** (Table 2). Thus all fields with severe (>5%) incidence are rejected and are only used for ware potato.

Leaf roll symptoms

Severe mosaic symptoms

Mild mosaic symptoms



Both severe and mild mosaics

4. Vector assessment

As far as viruses are considered in potato, vectors and their activity determine the quality of seed tubes produced from a particular seed crop. Aphids are known vectors of important viruses damaging potato in the country. And hence, inspectors should take note on aphid infestation in addition to these tolerance levels using the following scale:

- **Slight** (1 to 2 aphids on few plants)
- **Moderate** (1-10 aphids on most plants)
- **Severe** (>10 aphids on most plant)

When moderate to severe aphid infestation occurs in the field, the crop needs to be sprayed with registered and recommended pesticides. Primarily, areas with high vector activity are not suitable for potato seed production.

5. Field data recording

Field data recording is done using the following QDPM Data Recording Sheet-1 (Table 3). The recording is done for each field and decisions are taken right in field.

Table 3. QDPM Data Recording Sheet-1 for field inspection by COOPCOM and WERCOM

Multiplier:	*Field No:*	*Date:*
Variety:	*Rotation:*	*Isolation:*

Line	Off-types	Wilt	Viruses
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Total observed			
Tolerance level	**10 out of 1000**	**Nil**	**50 out of 1000**
Decision by COOPCOM:			
Decision by WERCOM:			
Recommendations:	**Late blight** = spray fungicide as the disease starts		
	Potato tuber moss = early and correct hilling		
	Virus vectors = early removal of potato haulms		

Finally, fields that do not fulfill these requirements should be rejected as QDPM fields. If more than 30% of the inspected fields of a given cooperative fail this inspection, the cooperative should be rejected as QDPM producer for this year.

4.2 Post-harvest inspection of potato for QDPM

The WERCOM inspects two aspects of post-harvest disorders that include (i) DLS management indicating the competence of the owner, and (ii) tuber quality indicating the planting value of the materials. One inspection is carried out by WERCOM while regular follow-up inspections are carried out by COOPCOM. All DLS are inspected and tubers assessed. When tuber assessment value exceeds the tolerance level indicated in Table 3, strong recommendations are imposed. If the producer doesn't take action, WERCOM may reject the tuber and hence QDPM tags are not provided. The inspection data is recorded in QDPM Data Recording Sheet-2 shown in Table 4. Details of the inspections are given bellow.

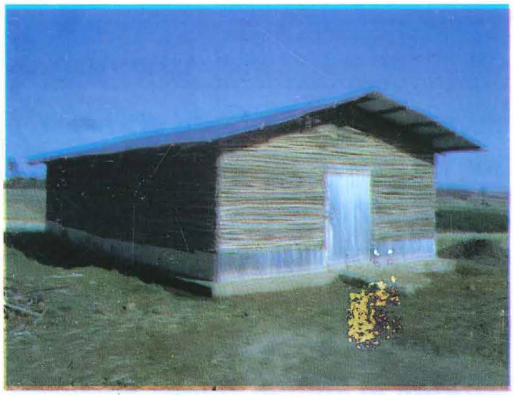
Table 3. Tolerance levels for imposing recommendations in post-harvest inspection

Defects/pests	Recommendations to be imposed
Graded (40 to 70g)	> 10% over- or under-size tubers found, **grading is needed**
Off-type/mixture	If any varietal impurities found, **sorting is needed**
Tuber rots	If rotting tubers found, **sorting is needed**
Defective tubers	If defective tubers found, **sorting is needed**
PTM	If PTM infected tubers or PTM moths are found, **dip of tubers in Diazinon solution and spraying of store is needed**
Aphids	If Aphids found inside DLS or on tubers, insecticide application is needed
Soil	If soil weight exceeds 2% of the total weight, **the tubers need to be cleaned**
Variety labeling & separation	**Varieties clearly labeled and separated by physical barrier**. If not, this needs to be done
Cleanness	Floor, unused benches and surroundings of DLS are free of rotten or dried up potato tubers and potato plants, if not, **cleaning is needed**
Tagging (1 tag per quintal)	Estimate quantity of clean seed tubers to **provide the correct number of tags for each producer**

(i) DLS inspection includes the following criteria.

- **Construction**: suitability for management and protection (including waste discharge),
- **Cleanness:** hygiene of the store (ground, benches, surrounding),
- **Tuber grading:** uniform in sizes, sorted for off-types, etc and
- **Variety separation:** labeling and presence of physical barrier.

The inspection teams evaluate each DLS using the above four criteria and rate as poor, fair, good or excellent. Poor DLS and tuber managements are rejected by WERCOM because they do not fulfill the QDPM standard.

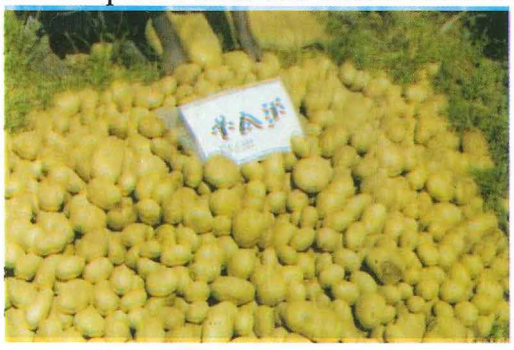


Excellent DLS and clean surrounding

Good tuber management

Poor DLS handling and tuber management

(ii) Tuber quality inspection includes the following: shape, size, color, sprout, etc are important variety criteria in inspecting tubers for uniformity. The tuber quality aspect includes varietal uniformity, defects and disease situations. Tuber size is used as criterion for quality grading of seed potato and the best quality seed potato has a weight of 40 to 70 grams. This is a medium size tuber recognized by most farmers. The WERCOM uses the tolerance level in Table 4 when assessing the tubers during post-harvest inspection period and impose strong recommendations in case of above tolerance level. Uniform sample is drawn by taking about 3 places from one bench. A minimum of 500 tubers are assessed for one variety.



Variety TOLCHA

Variety GUDENE

Variety GERA

Variety JALENE

(a) Off-type (different kinds of tubers from the true variety)

At least 500 tubers are assessed by WERCOM and only 5 defected tubers are tolerated in the QDPM standard. If the lot has more than 5 off-type tubers in the sample, sorting is strongly recommended as compulsory action (Table 3). If prompt actions are not taken by producer, WERCOM may reject the tuber from QDPM declaration and does not get tag.

(b) Inspection for tuber rots

Storage tuber rots can be caused by many diseases and insect damages, and also other factors. The rots caused by late blight, bacterial wilt, potato tuber moth, etc. are not sometimes easily recognized and hence the inspection teams assess these tuber rots together. Tuber rots can be recognized by visual observation and scraping of tuber skin or by cutting it. Cutting is done when suspected for infection; otherwise visual assessment is just enough.

Upon assessing 500 tubers from each variety, the inspecting team (WERCOM) may impose strong recommendations of sorting and then destroying the rotted tubers. If the action is not promptly taken by the producer, WERCOM rejects the tubers from QDPM declaration.

1. Late blight (*Phytophthora infestans*)

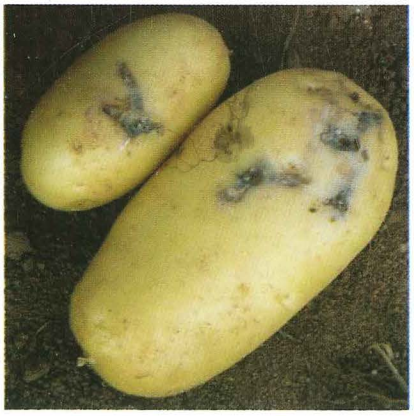
Tuber symptom of late blight

2. Bacterial wilt *(Ralstonia solanacearum)*

Tuber symptoms of bacterial wilt

3. Potato tuber moth

Larvae of potato tuber moth (PTM)

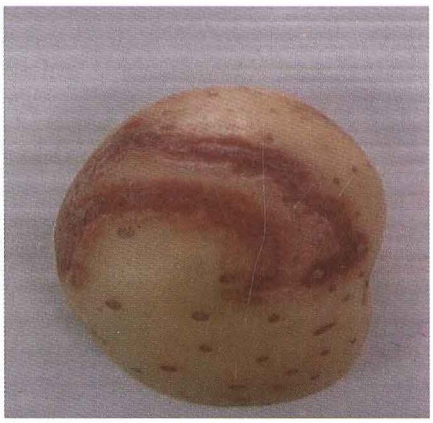


PTM and disease lesions on tubers

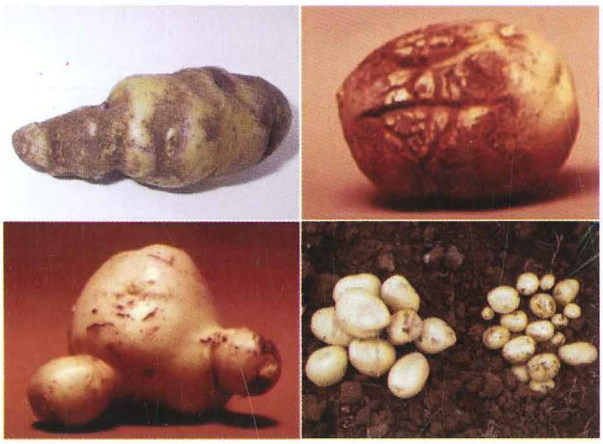
(d) Defective tubers

Different potato viruses and physiological disorders/conditions may cause tubers defective. These reduce tuber quality. When defective tubers observed, WERCOM may impose recommendation of sorting tubers. If the action is not taken, WERCOM rejects the tubers from QDPM declaration. Symptoms of defective tubers are given below.

Tuber necrosis caused by PVT



Tuber necrosis symptoms



Tuber virus symptoms

(d) Soil contaminations

Soil contamination reduces tuber quality as planting material because of carrying soil borne pathogens and nematodes. Thus, only up to 2% of the total weight is allowed to be soil in the QDPM standard. If soil weight exceeds 2% of the total weight, the tubers need to be cleaned. WERCOM verifies this contamination level and impose recommendation of tuber cleaning. If the action is not taken by the producer, WERCOM may reject the tubers from QDPM declaration.

Tubers contaminated with soils

iii. Data recording during post-harvest inspection by WERCOM and COOPCOM

The data of post-harvest assessment on off-types (mixture), tuber rots, defective tubers, PTM, aphid, soil contamination and quantity of tuber that should get tags are recorded in a table referred as **QDPM Data Recording Sheet-2** as given in Table 4.

Table 4. QDPM Data Recording Sheet-2 for post-harvest inspection by COOPCOM or WERCOM

Multiplier: *Variety:*			*DLS No:* *No tubers checked:*			*Date:* *Decision:*	
Variety	**Off-type/ mixture**	**Tuber rots**	**Defective tubers**	**PTM**	**Aphids**	**Soil**	**Quantity (quintals)**
Actions recommended: (sorting, spraying/ Deeping, cleaning, etc)							
DLS management status: (poor, fair, good, excellent)							
Total tags needed: (based on one tag per quintal)							
Re-inspection needs:							

5. LABELS AND TAGS

Proper identification is a prerequisite in recognizing a particular material and labeling is hence very important in this case. Labeling of the fields and DLS should be considered as follows:

5.1 Field Labeling

- Name of the producer (Cooperative)
- Location and contact,
- Name of the variety,
- Source of seed,
- Date of planting

5.2 DLS Labeling

- Name of the store owner (Cooperative),
- Store number,
- Capacity of the Store,
- Address

5.3 Bench Labeling

- Name of the variety,
- Date of harvest
- Quantity of seed tubers in quintals

5.4 QDPM Tags for the sacks (containers)

- Name of the producer (Cooperative),
- Address,
- Name of variety,
- Date of harvest,
- Quantity in quintals

6. AUTHONTICATION AND REGISTRATION

Based the data collected from field and post-harvest inspection, properly labeled fields and DLS, tubers managed, labeled sacks containing sorted tubers for quality, would provide the basis for validation of a particular seed tuber as QDPM of potato. Therefore, the WERCOM provides Cooperative members with letter of recognition declaring that it is a **QDPM of Potato Producer Cooperative for the Year YYYY**. This would be an incentive for the Cooperative/PLC to continuously improve the quality of potato seed they produce. Of course, ultimately the WERCOM provides Cooperative or PLC with **QDPM tags** only for the tubers harvested from inspected fields under QDPM scheme of that particular season. COOPCOM receives these tags from WERCOM and verify the labeling at farm level.

Generally, after successful completion of the DLS inspection and the estimation of the total quantity of seed stored, the owner will be given the corresponding number of tags (1 tag each for 1 quintal of seed). The tags need to be attached to the seed bags when they are being dispatched from the store. In case the store does not pass the inspection, the owner should be advised to rectify the situation and a date for a re-inspection should be agreed on. If the store fails the re-inspection, the seed will not be considered as QDPM seed.

7. COMMUNICATION AND PARTNERSHIPS

It is important to ensure a fruitful partnership between public, private and community-based organizations. Each one of them may directly or indirectly contribute to the success of the whole system, if their role is clearly recognized and appreciated by all stakeholders. Usually, farmers value the seed grown by trusted neighbors because they are more informed about the quality and the sources. Hence, farmers' informal network to exchange information on planting materials enhances the success of community-based organizations. Under this QDPM scheme, all partners at Wereda level should exchange information regarding potato seed.

1. The amount of seed tubers produced,
2. The quality status,
3. Name of the variety,
4. When and where it would be available, and
5. How can payments settled.

This network serves as a strong market linkage of seed potato in the locality. It may include the FG/Coop leaders, extension agents, researchers, and Wereda Agriculture Officials.

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